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OVERVIEW

As the new decade dawned, some auspicious energy indicators were evident, yet international concern continued at a high level.

Among the causes of this concern was the conflict between two major Middle East oil producers, Iran and Iraq, resulting in a sharp curtailment of exports. In addition, the Organization of Petroleum Exporting Countries (OPEC) added further increases to the sharp price escalation of 1979. The outlook for the less-developed oil-importing countries grew even bleaker as an already crippling debt load continued to increase once more. Once again, the industrialized countries suffered from inflation and recession, induced partly by the oil price escalation.

All this would have added up to a very grim scene if there had not been a scattering of unmistakably encouraging signs. While still far from finding an antidote to oil-induced inflation, the major oil-consuming nations at least appear to be more actively seeking ways to counteract the disease—with some modest evidence of success.

A potentially favourable omen was that, despite a sharp curtailment of oil available for export by OPEC, excessive demand for the remaining OPEC oil did not develop. In part this was a reflection of poor economic performance in the developed countries, but to some extent it was attributable to conservation and demand-restraint policies adopted by industrialized nations within the framework of the International Energy Agency and other international bodies.

Until this year, restraining the rate of growth of demand for oil worldwide had been an oft-repeated objective, which was not widely matched by effective programs likely to result in a substantive reduction of the number of barrels consumed.

By the end of 1980, however, there was evidence at several levels that potentially effective programs are emerging and, to some extent, are resulting in a real lowering of oil demand.

Internationally, as expressed in the communique of the Venice Summit Conference of leading industrialized countries, there was a strong collective endorsement of national efforts to conserve and to make greater use of other energy forms as a substitute for oil.

These "off-oil" programs, in gestation for several years, are gaining momentum, as are improvements in industrial energy efficiency and in automotive fuel economy.

All these factors, for instance, contributed to a sharp decline in U.S. oil consumption. This made an important contribution in restraining demand for OPEC oil, since the United States is the largest single importer of oil.

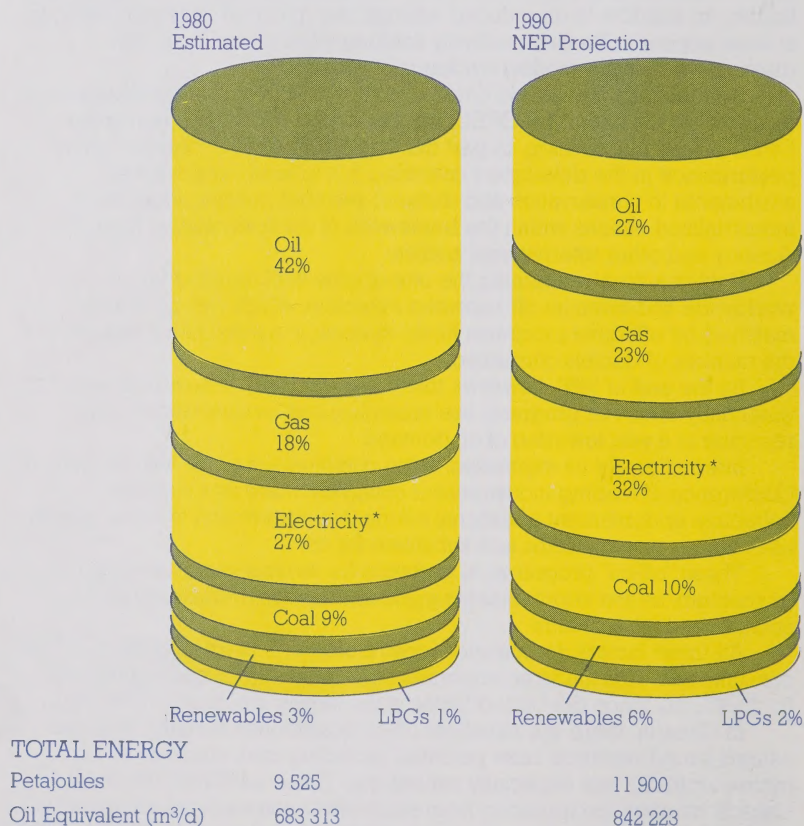
In Canada, there are excellent off-oil possibilities deriving from the nation's broad resource base potential, including coal, uranium, wood, hydroelectricity and especially natural gas. These resources will help Canada manage the transition from established conventional oil, which is declining, to the new unconventional and frontier oil which will become available in the late 1980s and 1990s.

To meet the broad challenge of energy development in a national framework, the Government of Canada introduced the National Energy Program (NEP) in October 1980. This program included, among other initiatives, several measures to encourage large-scale replacement of oil by natural gas, electricity and other energy forms in non-transportation uses. A slight decline in oil product demand was recorded in 1980, a trend that will become more pronounced as the new substitution and energy conservation programs are established.

Western Canadian conventional oil discoveries continued to be disappointing, despite unprecedented levels of investment by the oil industry. Overall production was down considerably in 1980, and a modest increase in net imports was recorded.

In sharp contrast to the Canadian oil outlook, natural gas production will continue to expand as a consequence of the very favourable

Energy Source Percentages



*These represent electricity generated by hydro and nuclear sources only.

exploration trend in western Canada and elsewhere. The increasing substitution of gas for oil will be encouraged by holding the price below that of oil, by consumer grants to enable furnace conversion and by extensions of gas pipeline systems into new eastern and western market areas.

The sharp escalation of world oil prices continued to have serious repercussions within Canada. It became more difficult to find a domestic oil pricing policy capable of reconciling the interests of oil consumers, who fear the inflationary impact of sharp price increases, with those of oil producers, who believe oil is increasingly undervalued in relation to the world price.

This matter was the subject of long and inconclusive negotiations between the federal government and the Government of Alberta. It did not prove possible to agree on oil pricing and revenue sharing arrangements that were acceptable to all concerned.

In the absence of agreement, the federal government exercised its national responsibility for energy management and introduced the National Energy Program. It established a new pricing and revenue sharing structure for oil and natural gas, to provide the certainty needed for industry decisions. Under this structure conventional oil prices will rise in accordance with a fixed schedule to 1990, and incentive or "reference" prices are provided for high-cost oil production such as synthetic crude oil from oil sands.

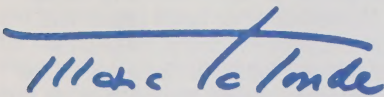
The NEP is founded on three basic goals, summarized as security, opportunity and fairness.

The specific target for energy security is independence from the world oil market by 1990, a challenging goal that will require a major emphasis on developing new oil supplies and reducing oil demand.

To ensure that Canadians have an opportunity to share fully in the growth of the energy industry, the program provides generous new incentives for Canadian investors and promises an increase in the public sector's share of industry ownership. The goals include 50 per cent Canadian ownership by 1990 and control of a significant number of the larger companies. More than 70 per cent of the industry's revenues went to foreign-owned companies in 1979, and more than 80 per cent to foreign-controlled firms.

The program established a petroleum pricing and taxing regime designed to accord fairness to all Canadians regardless of where they live, and to ensure the Government of Canada the financial means to carry out its national responsibilities in the energy field.

At the end of 1980, the challenge of meeting those goals continued to figure prominently in national affairs.

A handwritten signature in blue ink, reading "Marc Lalonde". The signature is stylized with a long horizontal stroke at the beginning and a large, sweeping "L" for the last name.

Marc Lalonde
Minister
Energy, Mines and Resources Canada

OIL AND NATURAL GAS

Pricing

Domestic oil prices continued their gradual move upwards, and Canadians, at the end of 1980, continued to pay less than consumers of most other countries. The price of conventional oil at the wellhead rose to \$92.82/m³ (cubic metre) in January 1980 under a federal-provincial

pricing agreement. Later, following the failure of Ottawa and Alberta to reach a new pricing agreement, Alberta increased the wellhead price \$12.59/m³ in August.

During 1980 Syncrude Canada Ltd. continued to receive the international price for its oil sands production. A tax on oil consumed in Canada is used to finance subsidies to refiners who buy this high cost domestic oil. This levy, which subsidizes the difference between domestic wellhead prices and world prices, increased several times during the year. In January 1980 the levy was \$5.35/m³; by October it was \$11/m³.

In the spring the Government of Canada announced it was reviewing its international price guarantee to oil sands production in view of extraordinary world oil price increases. This was in accordance with a special emergency clause in the agreement with Syncrude covering its synthetic oil price. Under the National Energy Program a reference price approach was subsequently established, giving oil sands plants a basic price escalated annually from the Consumer Price Index. This reference price was initially proposed at \$239/m³ for January 1981. However, the world price continued to be paid for Syncrude production pending Parliamentary approval of the legislation implementing the new reference pricing system.

The existing Suncor Inc. oil sands plant received the world price from April 1979 until November 1980. At that time it again began receiving the same price as producers of conventional oil, \$105.41/m³. The world price had been granted Suncor to help raise revenues for expansion of its output; it was withdrawn under the terms of the agreement after funds raised had exceeded those specified in the agreement. The reference price will be made available for the production from expanded facilities. Total cost of the levy to both oil sands plants—Suncor and Syncrude—was \$967 million in 1980.

While domestic price increases were kept moderate throughout 1980 the cost of importing oil into Montreal jumped 37 per cent, from \$163/m³ in December 1979 to \$223/m³ at the end of the year. The Oil Import

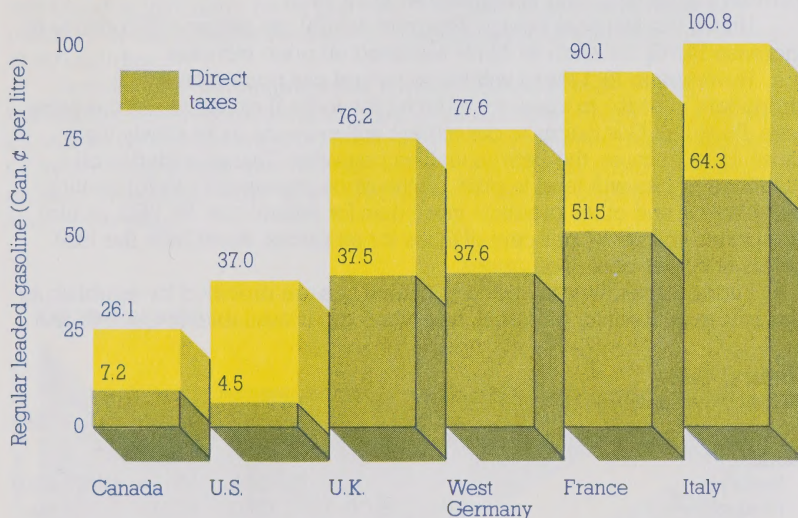
1 cubic metre (m ³)	=	220.00 Imperial gallons 6.29 U.S. barrels
1 joule (J)	=	1000.00 kilograms 0.009482 Btu (British thermal unit)
1 gigajoule (GJ)	=	0.93209 million Btu (gross heating value)
1 kilometre (km)	=	0.621371 miles

Compensation Program provides subsidies to refiners of imported oil equal to the difference between the domestic and average imported price at Montreal. These subsidies, which are determined monthly by the Government of Canada, increased from \$114.00/m³ in January 1980 to \$144.67/m³ in December. The cost of these subsidies was \$3 billion last year.

The Government of Canada invoked the *Petroleum Administration Act* in October to establish a new pricing scheme which provides a "blended" or Made-in-Canada price. This price will not exceed 85 per cent of world price. The blended price is composed of a weighted average reflecting the cost of conventional domestic oil, non-conventional oil (such as oil sands) and imported oil. It is this blended price that determines the cost to consumers. This cost will include the wellhead price of conventional oil and a new Petroleum Compensation Charge.

Comparison of Motor Gasoline Prices in Canada and Other Major Countries

(As of September 1980)



On January 1, 1981, when the price increases went into effect, the blended price was \$143.42/m³—\$111.65/m³ for wellhead price, and \$31.77 for the Petroleum Compensation Charge. The Petroleum Compensation Charge is a refinery tax, which is used to finance the synthetic oil subsidy and partially offset the cost of oil imports. General tax revenues will continue to be used to pay the remainder of the oil import compensation costs. The Petroleum Compensation Charge was established in November at \$16.04/m³ and is projected to increase \$15.73/m³ annually to 1983.

The National Energy Program introduced a Canadian Ownership Account to be financed by special charges on oil and gas consumption in Canada. It will be used to finance an increase of Government ownership in the energy sector.

Under the new scheme wellhead prices of conventional oil will continue to move up steadily over the next 10 years, slowly at first, more quickly later. Production from oil sands and tertiary sources will receive preferential reference prices reflecting their costs and providing adequate returns on investment to the industry.

Responding to the initiatives by the Government of Canada to establish a pricing schedule, the Alberta government announced a phased production cutback to 85 per cent of 1980 production levels for conventional oil over a nine month period starting March 1981. Alberta also said it would not grant approvals to proposed oil sands plants until agreement is reached on a pricing schedule, and challenged in court the legality of the natural gas excise tax.

Natural Gas

Natural gas prices as measured at the Toronto city gate continued to follow oil prices upward, increasing 14¢/GJ (gigajoule) for each \$6.29/m³ increase in the wellhead price of oil. Tracking oil price increases, gas prices rose in February to \$2.14/GJ and in September to \$2.42/GJ.

Under the National Energy Program natural gas prices will continue to increase 14¢/GJ for each \$6.29/m³ wellhead oil price increase.

However, in 1981 there will be no natural gas price increase to producers in order to make room for a new federal excise tax on gas sales (see Taxation). Gas prices to consumers will increase more slowly than those of oil because the Petroleum Compensation Charge added to oil wellhead prices will tend to push up the price consumers pay for heating oil, gasoline and other products more than for natural gas. By 1983, natural gas prices will be 67 per cent of those for oil prices, down from the 1980 levels of 80 per cent of oil prices.

Further incentives to switch to natural gas are provided by establishing gas prices in Toronto, Montreal, and when gas is available, in Quebec and

Natural Gas

Billions of cubic metres

	1970	1975	1979	1980
World¹				
Reserves	n.a.	72 107.0	70 716.0	72 892.0
Production	1 079.0	1 337.0	1 630.0	n.a.
Canada²				
Conventional Reserves				
Initial Recoverable	1 908.0	2 292.0	2 852.0	2 983.0
Remaining	1 560.0	1 623.0	1 906.0	1 956.0
Frontier Reserves	n.a.	n.a.	410.8	410.8
Production ³	52.1	69.3	75.3	69.8
Consumption ³	29.5	41.2	46.2	47.6
Exports ³	22.1	26.8	28.3	22.5
Imports ³	0.3	0.3	0.0	00.0
Net Exports	21.9	26.5	28.3	22.5

¹American Petroleum Institute

²National Energy Board (as of January 1)

³Energy, Mines and Resources Canada

Halifax, at the same level.

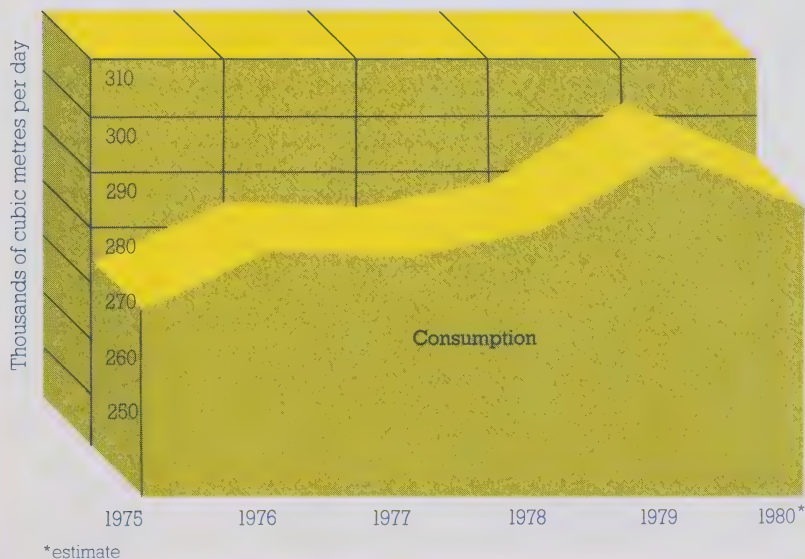
Natural gas export prices increased once in 1980, on February 17, from \$US 3.45 to \$US 4.47/MM Btu (million British thermal units). The pricing of gas exports is based on the substitution value of gas for oil imported into Canada and an assessment of the U.S. market situation. Following the 30 per cent increase in February an agreement was signed with the United States to provide them 75 days notice of any further increases.

Production, Consumption, Exports and Imports

Total production of crude oil and equivalents (excluding LPGs—liquid petroleum gases) decreased by 3.5 per cent from 1979 levels. Light and medium conventional crude oil production from western Canada declined in 1980 by 8.3 per cent to 173 900 m³/day while heavy oil output increased by 3.4 per cent from 1979 to 33 900 m³/day. Synthetic crude oil output increased significantly, by 34 per cent from 1979 as Syncrude Canada reached its full capacity. Average production level for synthetic crude was 19 400 m³/day.

Domestic oil consumption was 2.2 per cent lower than in 1979, reflecting increased conservation, substitution of other energy sources for oil and an economic downturn. This reduced consumption helped maintain oil inventories at high levels throughout the year. Crude oil and petroleum product inventories were 4 per cent higher at the end of 1980 than at the start of the year.

Oil in Canada



Licensed exports of crude oil decreased 22 per cent to 14 200 m³/day, from 1979 levels, while exports of petroleum products showed a 10 per cent increase to 19 900 m³/day. Oil exports consisted of heavy oil from Saskatchewan and Alberta and represented 42 per cent of heavy crude production. This oil is considered surplus to Canadian needs because of a lack of necessary refinery facilities within Canada to handle it. There were no exports of light or medium crude oil during the year.

Mid-continent exchanges took place at about the same rate as last year. These exchanges allow delivery of Canadian oil to U.S. refiners in the Northern Tier area who have no alternate sources, with an equivalent amount being delivered to eastern Canada, resulting in no net export or import change.

Overall petroleum imports for domestic consumption were down about 7 per cent from the previous year.

Canada continued to receive most of her imports from two countries: Venezuela, which accounted for 38 per cent of total imports excluding exchanges from the United States; and Saudi Arabia, which accounted for 50 per cent. This is a marked reversal over previous years when Venezuela was our largest supplier, and reflects in part the reduced producibility of Venezuelan oil fields. As part of the Government's efforts to diversify oil sources, the first state-to-state deal was concluded between Petro-Canada and Mexico in April. While the agreement allows for delivery of up to 7945 m³/day of Mexican crude, first deliveries were made in November at the rate of 810 m³/day. This was due to technical difficulties in Mexico, which were expected to be overcome in 1981.

Canada agreed with the International Energy Agency to a net petroleum import target (excluding ethane) of 150 000 barrels/day. Actual net imports, measured against this target, were 163 000 barrels/day in 1980.

In other aspects of production, Alberta changed its method of handling

Oil

Millions of cubic metres

	1970	1975	1979	1980
World¹				
Reserves	84 307	113 210	101 984	102 048
Production	2 657	3 099	3 618	n.a.
Canada²				
Conventional Reserves				
Initial in place	n.a.	2 192	2 264	2 287
Remaining	n.a.	1 092	866	806
*Production ³	86	100	106	103
*Consumption ³	85	100	111	109
*Imports ³	44	50	37	35
*Exports ³	44	52	33	28
Net Imports	0	-2	4	7

*Note: Figures include liquid petroleum gases.

¹American Petroleum Institute

²National Energy Board (as of January 1)

³Energy, Mines and Resources Canada

sales of crude oil out of the province. Starting in May 1980 the Alberta Petroleum Marketing Commission was named the sole purchaser of Alberta crude oil.

Refinery Upgrading

Steps were taken during the year that will result in more effective utilization of our available oil supplies and a reduction in the surplus heavy fuel oil.

Eastern Canadian refineries, built when light crude was abundant and ready markets existed for heavy fuel oil, cannot efficiently handle either the heavier crudes being sold on the world market or our domestic heavy crude oil. In order to produce the needed gasoline and diesel fuels, larger amounts of heavy fuel oil would also be produced. This heavy fuel oil is a direct competitor with natural gas for industrial use and inhibits gas substitution. Refinery modification to eliminate surplus heavy fuel oil production in eastern Canada will provide additional needed petroleum product without requiring additional crude oil.

Three eastern Canadian refineries have agreed to undertake refinery modifications, which will eliminate 11 100 m³/day of heavy fuel oil by 1984. The refineries involved are owned by Ultramar, Inc., Suncor, Inc. and Petrosar Inc. During the year Gulf Canada closed its 12 900 m³/day Point Tupper, Nova Scotia refinery, which was a significant producer of heavy fuel oil and thereby reduced some of the surplus refinery capacity in eastern Canada.

In October Petro-Canada completed a preliminary feasibility study regarding a central upgrader to serve the needs of the Montreal refiners. It is now participating in a task force consisting of these refiners, and Soquip, a Quebec government corporation, to make a detailed assessment of the project. Such a facility could deal with heavy fuel oil as well as upgrade heavy crude oil. By 1985 between 10 000 and 20 000 m³/day of heavy fuel oil could be eliminated by this project.

In November Petro-Canada retained an option to purchase the idle Come by Chance refinery in Newfoundland.

Western Canada requires additional refining capacity to handle the increasing volumes of synthetic oil coming on stream. Gulf Canada Ltd. and Imperial Oil Ltd. have both announced plans to undertake refinery expansions. Shell Canada Ltd., working with Husky Oil Ltd., has also announced its intention to construct a new refinery. These projects, to be completed by 1984, will increase refining capacity in western Canada by 22 250 m³/day. In addition, Turbo Resources expects to complete work by 1983 on a new 3178 m³/day refinery started this fall.

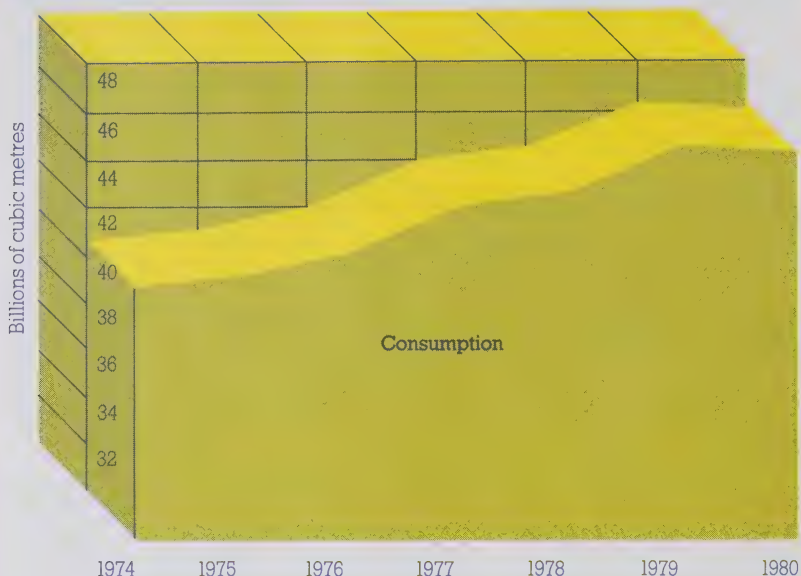
Natural Gas

Natural gas sales to domestic and export customers both decreased during the year. Sales to domestic residential customers decreased by around 0.1 per cent. There was a moderate 5.6 per cent drop by industrial users of Ontario. Commercial consumption increased by 9.2 per cent. Total domestic demand for natural gas in 1980 was approximately 47.6 billion m³.

Gas sales to the U.S. market experienced a decline of around 21 per cent, reflecting a combination of factors: a mild American winter, increased gas production in the United States, and buyer resistance to the price of Canadian gas. Total export demand for natural gas in 1980 was

approximately 22.5 billion m³. Despite this lowered demand, revenues from export sales were close to \$4 billion in 1980 compared to \$3.06 billion in 1979.

Natural Gas in Canada



Exploration and Reserves

Western Canada

Exploration for oil and gas in western Canada increased rapidly in 1980, surpassing the record level of drilling activity in 1979. The number of exploratory wells drilled was almost 30 per cent higher.

However, production of conventional oil continued to outpace additions to reserves.

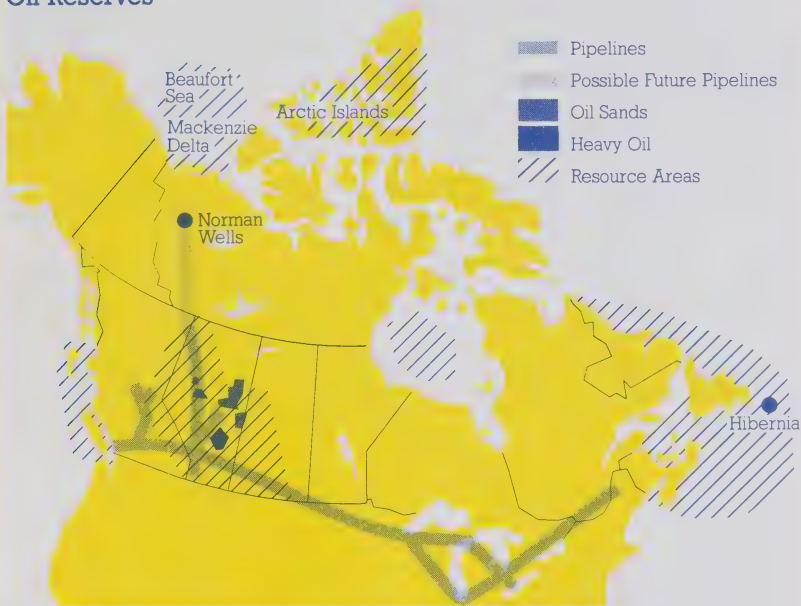
Producibility of conventional oil and petroleum liquids in western Canada is expected to decline from 237 100 m³/day in 1980 to 186 300 m³/day in 1985.

The Geological Survey of Canada released its latest projections on undiscovered oil and gas reserves in September, 1980. The Survey estimates a 50 per cent probability that 0.4 billion m³ of conventional oil will be discovered in western Canada during the 1980s.

In recent years, gas has been discovered at a faster rate than oil, a trend the Geological Survey says will continue in all exploration areas. In 1979 approximately 175 billion m³ of natural gas were added to reserves in western Canada, bringing the total Canadian reserves to 2.5 trillion m³ in 1979. It is estimated an additional 1 trillion m³ of gas will be discovered during the 1980s.

Because of limited markets for natural gas, new discoveries are shut in for future use. The need to find additional domestic markets for our growing supply of available natural gas is underlined by the fact that Canada continues to use almost two and one-half times more oil than natural gas annually, despite the fact that there is now approximately 50 per cent more accessible energy in the ground in the form of gas than there is of conventional oil.

Oil Reserves



Offshore and Frontier

Exploration in the frontier areas of the Arctic Islands, Beaufort Sea — Mackenzie Delta, and offshore East Coast proceeded at about the same pace in 1980 as the previous year. Total exploration expenditures during the year amounted to approximately \$730 million, of which \$116 million was contributed by Petro-Canada. The Geological Survey estimates that a minimum total of 1.9 trillion m^3 of gas and 826 million m^3 of oil could be discovered in these regions during the decade.

Major exploration efforts last year were as follows:

- Dome Petroleum Co. Ltd. continued its fifth year of exploratory drilling in the Beaufort Sea in an attempt to confirm the commercial prospects of the area.
- Four drillships were employed in 1980, but the season was the shortest ever experienced by Dome because of the severity of the ice conditions. The company was attempting to evaluate the potential of the Kopanoar oil discovery of 1979, and also announced the successful completion of the

testing of Tarsiut A-25, which yielded both oil and gas. Dome also began work on construction of artificial drilling islands in the area.

- In the shallower waters of the Beaufort Sea, Esso Resources Canada Ltd., active in the area since 1974, continued exploratory drilling from dredged artificial islands. During 1980 a significant oil and gas discovery was made.
- Panarctic, operating in the inter-Arctic islands region for several companies, including Petro-Canada, reported one gas discovery at Char and drilled a well to evaluate the Whitefish gas discovery of 1979.
- Summer drilling in the Labrador Shelf area utilizing three rigs, continued as Petro-Canada took over as operator from Total Eastcan Exploration Ltd., which had been leading the Labrador Group of companies since 1973. While several gas discoveries have been made to date, none of these appears to be of commercial significance. A fourth drilling unit was operated by Chevron in the same area. There were no further discoveries in 1980.
- The first delineation well of the Venture gas discovery of 1979, located east of Sable Island, was started in August; it was still being drilled at year's end.
- The Hibernia structure, located off the Grand Banks, continues to be the most significant frontier discovery to date. Two delineation wells to the Hibernia discovery of 1979 were drilled during the year. Results of this drilling have led to estimates of recoverable oil reserves ranging from 150 million to 250 million m³ of oil in place. The oil in Hibernia so far has proven to be of very high quality. Operator for the consortium, which includes Petro-Canada, is Mobil Oil Canada Ltd.

The companies are proceeding with plans on how to get the oil to markets. But, before any production could begin, a jurisdictional dispute between Newfoundland and Ottawa must be resolved. During the constitutional discussions in the summer of 1980, the Government of Canada offered to allow the provinces to obtain 100 per cent of provincial-type resource revenues from offshore fields and to give the provinces a substantial voice in the management of the resources. This offer was withdrawn following the breakdown of constitutional talks in September. However, as stated in the National Energy Program, the Government of Canada remains determined to take into account the needs of the region and continues to believe that a resolution of the legal issues in the dispute is desirable.

Companies operating in the frontier and offshore areas in the future will be operating under new rules. The proposed *Canada Oil and Gas Act*, introduced into Parliament in December, will cover exploration and development on lands under direct federal government control, known as Canada Lands. Features of the Act will reinforce the Canadianization thrust of the National Energy Program through ownership requirements for production and through requirements for allowing federal participation in exploration and development. The Act will also have regulations to ensure active exploration and development of oil and gas resources through stricter work requirements. This will encourage development and contribute to security of supply and energy self-sufficiency. And it establishes a royalty system, including a Progressive Incremental Royalty,

which provides higher royalties based on the profitability of fields after production begins.

Oil Sands and Heavy Oil

The oil sands and heavy oils of Alberta and Saskatchewan are among the world's largest known hydrocarbon deposits, and as much as 32 billion m³ of oil may ultimately be recoverable from these deposits.

There are five principal locations of these deposits; Athabasca, Peace River, Wabasca and Cold Lake in Alberta and the Lloydminster area straddling the Alberta-Saskatchewan border.

The largest deposits are in the Athabasca region where some of the mixture of sand and heavy, thick molasses-like oil or bitumen is close enough to the surface to be recovered by surface-mining techniques. The two operating oil sands plants employ these techniques. The Alsands plant is proposed for this area, as is the project proposed in 1980 by Petro-Canada and Nova, an Alberta corporation, for completion in 1990.

The oil sands of the Peace River and Wabasca areas are similar in characteristics to those of Athabasca, but generally deeper in the ground and require in situ recovery. The bitumen deposits of Cold Lake are less viscous than those of Athabasca. This oil must be recovered through in situ methods, as proposed by Esso Resources Ltd.

The Lloydminster heavy oils, less viscous than the oil sands, can be recovered to some extent using methods similar to those employed in enhanced conventional oil recovery.

What these oils all have in common is that recovery of them is technologically complex and economically expensive. In all cases the oil requires upgrading before it can be transported and utilized easily by refineries. Their advantage is that they are a *known* reserve.

Research is continuing on technology to improve the in situ and other enhanced recovery for oil sands and Lloydminster heavy oils. Recovery rates can be raised up to 40 per cent of the oil in place. There are several experimental enhanced recovery schemes funded by private industry and through incentives provided by both provincial and federal governments. In the NEP the Government of Canada offered to fund jointly with Saskatchewan a five-year \$50 million heavy oil research and development centre for enhanced recovery and other technology.

The Government of Canada reaffirmed its commitment to the construction of oil sands plants, upgrading facilities, and tertiary or enhanced recovery projects through new tax and price incentive proposals in the NEP. The federal government also made a commitment to participate in the financing of a heavy oil upgrader in Saskatchewan. A large portion of current heavy oil output is exported because Canadian refineries are not equipped to handle large volumes of heavy crudes.

During 1980 the two operating oil sands plants—Syncrude Canada Ltd. and Suncor Inc.—averaged production of 20 000 m³/day, an increase of 34 per cent over 1979. Syncrude Canada, reached a production level of 16 367 m³/day for a period during the summer. Suncor operated at its capacity of 7150 m³/day during the year. However, problems in production continued to be experienced occasionally by both plants.

Progress on the 20 000 m³/ day Esso Resources Ltd. heavy oil plant at

Cold Lake and the 23 000 m³/ day Alsands oil sands plant remained static during 1980. The necessary provincial approvals were not forthcoming because of the lack of a federal-provincial pricing agreement. Because of continuing delays Imperial Oil Ltd. was granted a \$40 million operating loan in November by the federal government for its Cold Lake project. In December, Alsands announced possible delays in the construction of its project.

Petro-Canada and Nova proposed a fifth oil sands plant during the year. The plant would have a production level of 21 000 m³ /day with a possible start-up date of 1990.

Transportation

Natural Gas Systems

Two major pipeline projects received National Energy Board (NEB) approval during the year.

Construction was begun on the first, or pre-build portion, of the Alaska Highway Natural Gas Pipeline, following NEB approval in July. The full pipeline proposal calls for a pipeline to carry natural gas from Prudhoe Bay, Alaska through Canada to U.S. markets. The pre-build section, built by Foothills (Yukon) PipeLine Ltd., a consortium of Westcoast Transmission Co. Ltd., Nova and TransCanada PipeLines Ltd., will carry surplus Alberta gas to U.S. markets. Start-up date for the exports passing through the western leg is expected to be May, 1981, for the eastern leg, November, 1982. Exports have already been approved by the NEB, through the western leg for Pan Alberta Gas Co. Ltd., and through the eastern leg for Pan Alberta Gas Co. Ltd., Consolidated Natural Gas Co. Ltd. and ProGas Ltd. Upon full completion, the line is expected to transport 68 million m³/day of gas from Alaska to the United States.

Approval was granted in August to the application of TransCanada PipeLines Ltd. (TCPL) to extend the natural gas transmission system from Montreal, currently the eastern terminus of the gas pipeline system, to Quebec City. Gas could be flowing through this line by late 1981 provided all federal and provincial approvals are forthcoming. In August the NEB denied the application of Q and M Pipe Lines Ltd. to build a pipeline to the Maritimes on the grounds that further environmental work and assessment of gas resources off Nova Scotia were required. Subsequently, TCPL and Q and M formed the TransQuebec and Maritimes Pipeline and, in late December, resubmitted an application for extension of the transmission system to the eastern townships of Quebec, New Brunswick and Nova Scotia. The application was expected to be heard by the NEB in the spring of 1981, with pipeline completion possible by the end of 1983. Construction of these pipelines would allow most major areas in the east, except for Newfoundland, Labrador and Prince Edward Island, to be served by gas.

Proposals have been advanced by Westcoast Transmission Co. Ltd., British Columbia Hydro and Centennial Pipeline Co. to build a pipeline to Vancouver Island—the only major western area not served by gas.

Sponsors of the Arctic Pilot Project, which include Petro-Canada, Nova, Dome Petroleum Co. and Melville Shipping Ltd., filed an application with the NEB in mid-October 1980. The group proposes to ship 6.4 million m³/day of natural gas by two ice-breaking LNG (liquefied natural gas) tankers from

Melville Island in the eastern Arctic, where it will be liquefied, to a terminal either in Quebec or Nova Scotia. There the LNG would be regasified and moved by pipeline into eastern Canadian markets. As initially proposed an equivalent volume of "exchange" gas would be exported through existing pipeline facilities from western Canada to the United States. An additional 6.4 million m³ of Alberta gas would be exported for a total export of 12.8 million m³/day. Cost of the project is estimated at over \$2 billion with the earliest start-up date 1986.

Another project still on the drawing board is that of Polar Gas. Polar Gas has proposed to construct a 5000 km (kilometre) long Y-shaped pipeline connecting both Arctic Islands and Mackenzie Delta gas reserves for delivery to Canadian markets at a cost estimated to be around \$15 billion. The earliest start-up date would be 1990.

Gas Resources



Oil Transportation

The National Energy Board reviewed an application from Interprovincial Pipe Line (NW) Ltd. to construct a 866 km crude oil pipeline from Imperial Oil Ltd. reserves at Norman Wells, Northwest Territories, to existing pipelines in Zama, northern Alberta. The pipeline throughput would be 4000 m³/day. The application for the project, estimated to cost \$360 million, is pending with the NEB. If approved in early 1981, construction could be completed by 1983.

To bring Alaskan crude oil to markets in the Northern Tier section of the United States, Trans Mountain Pipe Line Co. Ltd. has proposed to build

a port at Low Point, Washington and from there carry Alaskan crude by pipeline to Edmonton. At Edmonton, the oil would go through existing pipelines to the central United States. The estimated cost of the system, which will carry 80 000 m³/day of oil, is around \$600 million. Trans Mountain's application has been under consideration by the NEB since mid-1979. The NEB completed its review of the Canadian portion in early 1980, but Trans Mountain was required to do further environmental studies on the marine environmental impact on Canada of the U.S. portion. The hearing reconvened in November 1980 and continued into early 1981. The project competes with an all-U.S. proposal, The Northern Tier Pipeline, which is still under review in the United States.

Taxation and Revenue Sharing

A number of changes were made in the tax structure as it applies to the petroleum industry in 1980. The changes are designed to shift the exploration emphasis to the frontier and offshore areas and to encourage the Canadianization of the industry.

In March the frontier exploration allowance expired. This so-called "super depletion" allowance enabled companies and investors to benefit from tax write-offs up to 200 per cent of costs in frontier exploration wells over \$5 million. A new system was established, whereby, by 1984, depletion allowances for exploration will be phased out on provincial lands. Depletion allowances were discontinued in 1981 for all conventional oil development. Depletion allowances of 33 ⅓ per cent of qualifying expenditures will continue for frontier and offshore exploration, oil sands plants, and heavy crude oil upgraders and tertiary recovery projects.

The National Energy Program proposed tax and revenue sharing changes resulting from several significant developments that occurred during the 1970s.

Generous tax allowances in place were geared to developing a strong oil industry without regard to ownership. Higher petroleum prices left the industry as a whole with unprecedented profits, much of this in the hands of foreign-owned companies. Net oil and gas production revenues rose from \$1.2 billion in 1970 to \$11.1 billion in 1979; this occurred while production volumes increased only 30 per cent during the same period. In general, because of the high prices and generous tax incentives the industry could finance its investments internally. At the same time some of the revenues were being used to diversify into non-energy sectors, and to increase dividend payments abroad.

Producing provinces benefitted substantially from increased petroleum prices through ownership of the resources and economic benefits of the resource boom. Provincial governments received more than three quarters of the oil and gas production revenues accruing to governments. Because of the revenue sharing system in effect, the provincial share of oil and gas revenues increased from 38 per cent in 1974 to 48 per cent in 1979, taking into account land bonus payments.

At the same time, the Government of Canada's share of revenues from oil and gas production was only 8.8 per cent in 1979, having fallen from 11.6 per cent in 1977. This reduction occurred partly as a result of the *Income Tax Act* providing generous incentives to the industry to reinvest. This

percentage did not provide the Government of Canada with adequate funds to carry out its responsibilities.

The National Energy Program proposals were designed to address these difficulties while still allowing adequate revenues for the oil industry and the provinces.

The proposals include an 8 per cent petroleum and gas revenue tax, effective January 1, 1981. It is levied on net revenues of oil and gas production and applies to all individuals and business firms operating in Canada.

Federal taxes were placed on all sales of natural gas and natural gas liquids (ethane, butane, propane). A 28¢/GJ tax was set November 1, 1980, for domestic sales with a similar tax effective February 1, 1981 for export sales. Further increases of 14¢/GJ each are scheduled for July 1, 1981, January 1, 1982 and January 1, 1983.

The oil export charge, equal to the difference between domestic and export prices, is continued. But, effective November 1, 1980, 50 per cent of this charge will be rebated to the producing provinces.

The higher prices granted to oil importers and producers of non-conventional oil will be financed through a Petroleum Compensation Charge, which is levied on all domestic refiners (see Pricing). In addition, a Canadian Ownership Account Charge will be levied, as discussed under Pricing.

Canadian Ownership and Incentives

A major goal of the National Energy Program is to increase Canadian ownership of the oil and gas production industry to 50 per cent by 1990, while achieving Canadian control of a significant number of the larger firms. Canadian ownership and control have been slowly increasing since the early 1970s. The NEP policies will encourage Canadian-owned firms to grow quickly and will facilitate the participation of more Canadians in the industry, either through private or Government ownership. Of the top 25 petroleum companies in Canada in 1980, 17 were more than 50 per cent foreign owned and foreign controlled, and these 17 accounted for 72 per cent of Canadian oil and gas sales. Incentives will be geared to assist Canadian companies while, at the same time, foreign-owned companies will have sufficient revenues with which to expand.

The Petroleum Incentives Program, which in part replaces certain depletion allowance provisions, will be the chief instrument for increasing Canadian participation; it will be administered by the Petroleum Incentives Board. The incentives system will provide direct grants for exploration and development to companies, individuals and other entities who qualify under the program. This will provide an opportunity to Canadian companies, which, for the most part, are smaller and were not able to take advantage of the depletion allowances. The incentive grants are on a sliding scale, depending on the area of exploration and development and the amount of Canadian ownership of the participants. Maximum incentives, up to 80 per cent of qualifying costs, will be available for exploration in the offshore and frontier areas. The maximum grants will go to companies with, initially, 65 per cent Canadian ownership. The eligibility standard will rise by 2 percentage points annually to reach 75 per cent in 1986. All companies

exploring on Canada Lands are entitled to a basic incentive grant of 25 per cent of qualifying costs; in return the Government of Canada reserves the right to acquire a 25 per cent working interest in the oil and gas discoveries prior to approval of a production system.

A Canadian Ownership Rate (COR) was established to determine eligibility for incentive payments and for qualifying for other programs where Canadian ownership is required. It is administered by the Petroleum Monitoring Agency, established in August, 1980.

The Petroleum Monitoring Survey has been published annually since 1978, first by Energy, Mines and Resources Canada, and, since August, by the Petroleum Monitoring Agency. The industry's performance for the first six months of 1980, as shown in the *Monitoring Survey, 1980, First Six Months* indicated that industry profits continued to rise despite a decrease in production volumes. Cash flow increased 42 per cent over the same period in 1979 as a result of higher oil prices and improved profit margins in refining and marketing areas.

In addition to the Petroleum Incentives Program, there is a broad range of policies designed to increase the amount of Canadian ownership in the industry.

The Canada Oil and Gas Act requires a 50 per cent Canadian ownership rate before production can begin on Canada Lands.

The Government of Canada intends to purchase some foreign-controlled firms. Initially, this will be carried out by Petro-Canada and financed through the Canadian Ownership Account Charge.

Use of Canadian goods and services in the Canada Lands and on non-conventional oil projects will be encouraged.

The National Energy Board will be asked to take Canadian ownership levels into account when considering export applications, with preference to be given to Canadian companies.

A Natural Gas Bank will be established to assist Canadian gas producers experiencing financial difficulties because of limited markets.

REPLACING OIL

Objectives

To sustain Canada's energy security in the long run, efforts will be needed to reduce energy consumption and develop alternative, sustainable forms of energy supply to reduce our dependence on expensive, imported oil and achieve energy self sufficiency. This can be achieved by:

- Exploration, development and production of domestic oil supplies;
- Reduced consumption of oil products, as part of a rapid improvement in the efficiency of energy use; and
- Rapid substitution from oil to more plentiful Canadian energy sources.

In 1980 oil accounted for about 43 per cent of our energy, a decrease of about 2 percentage points in three years. The Government of Canada wants to hasten this trend. The National Energy Program strongly reaffirmed this commitment to decrease the use of oil; the NEP sets as an objective to reduce the use of oil to no more than 10 per cent of total non-transportation energy used in each province, by 1990. Converting from oil in the residential and industrial and commercial sectors is not technologically difficult.

Conversion Assistance

The Canada Oil Substitution Program (COSP) was introduced in October 1980 as a cornerstone of the Government's intention to switch off oil to alternate energy sources—natural gas, hydroelectricity, coal, nuclear and renewable. The COSP consists of two elements, one providing assistance for off-oil conversions and the other for distribution systems.

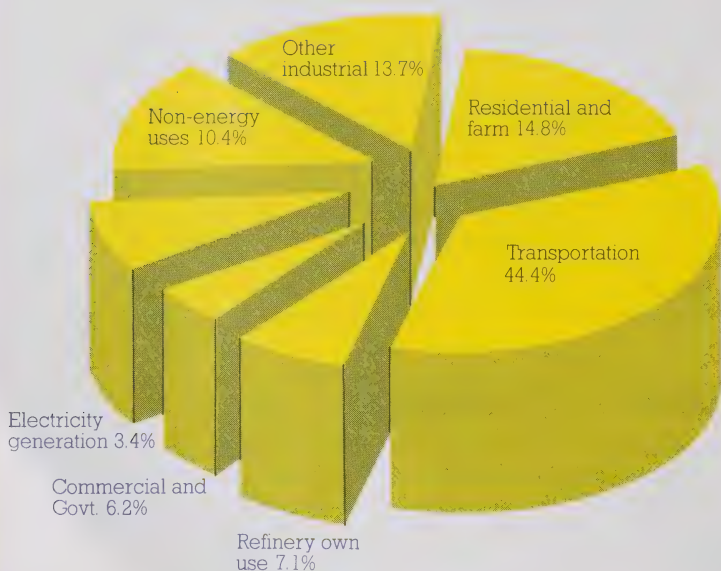
Under the National Energy Program the price of oil will rise to levels that make other fuels, especially natural gas, attractive on price alone. However, for many households and small businesses the initial cost of replacing an oil-burning furnace with a natural gas furnace or with electric heating is still too expensive. Therefore, taxable grants of 50 per cent of the conversion cost, up to a maximum of \$800, will be made available to help cover the expenses of converting away from oil. Alternatives that qualify include natural gas, electricity (not produced from oil-fired generators), solar heating, peat, wood and propane. These grants will be available across the country.

In addition, consumers in Prince Edward Island, Newfoundland, Northwest Territories and Yukon Territory will be eligible for special grants. Because of the lack of early access to natural gas and electricity in these areas, consumers in these locations can apply grants towards oil

furnace retrofits, insulation and other conservation-related investments, as well as qualifying furnace conversions. These will also be taxable grants of 50 per cent of costs up to a maximum of \$800. Consumers in these areas will also be eligible for an audit to determine the best conversion-retrofit package for their needs.

The major effect of the COSP is expected to be in eastern Canada where imported oil accounts for one half to three quarters of the energy consumed. In contrast, in the Prairies oil accounts for about 10 per cent of energy used in the non-transportation sector. However, to enable substitution away from oil to natural gas—where the greatest thrust of oil substitution is expected—transmission facilities must be put in place. COSP intends to encourage their construction.

Oil Consumption by Sector



The construction of the natural gas pipeline to Quebec City approved by the National Energy Board in 1980 will allow consumers in Quebec to switch off oil beginning in 1982. The extension of the pipeline to Nova Scotia, which the federal government will assist in financing if needed, will provide consumers in Atlantic Canada the opportunity to switch to natural gas by 1983.

Assistance will also be offered for the expansion of distribution systems for natural gas, electricity and propane; the development of alternate forms of energy in remote communities, and for renewable energy.

The federal government also established a fund to finance conversions in federal government buildings and facilities owned by Crown corporations.

By 1990, because of the incentive price for natural gas, the assistance provided consumers to convert off oil, and the development of required infrastructure, the Government projects 2.3 million household and 140 000 commercial and industrial conversions will have taken place. Of these, 1.5 million household and 100 000 business conversions will occur in Quebec and Ontario.

Transportation

While substitution for gasoline in automobile use poses a few more problems than conversions in the non-transportation sector, there is scope for reducing our demand for oil even here.

One alternative fuel that could be converted for use in automobiles fairly easily is propane. Canada produces a surplus of propane. Just over 50 per cent of our propane production of 19 000 m³/day was exported in 1980. Propane is a liquid gas produced as part of the production from gas plants and oil refineries, and its volume is forecast to increase as additional energy projects come on stream. Currently, its use is limited largely to heating, mostly in the west, and some agricultural uses such as crop drying.

The technology for conversion of automobiles to propane use already exists. And the economics are favourable. Several provincial governments have already taken action through the tax system to promote the use of propane and other alternative fuels in automobiles. During 1980 Ontario removed the sales tax on propane, manufactured gases and gasohol, and on alternatively powered vehicles. British Columbia reduced taxes for propane and on propane converter kits. Manitoba encouraged gasohol production through removal of the road tax on the sale of gasohol.

The federal government has taken these incentives further. Taxable grants of up to \$400 for each vehicle will be provided to encourage conversions to propane. The grants are restricted to commercial fleet conversions—taxis, utility trucks, delivery vans—at this time because of current propane marketing conditions. The federal government has set a target to convert 8000 of its own vehicles to propane over the next five years.

The Government has also served notice that the growing petrochemical industry should develop on feedstocks other than oil. Petrochemical plants, for the most part, can use LPG, natural gas or coal as a feedstock. As a goal, the Government would like the petrochemical industry to use no more oil in 1990 than it did in 1980. This would mean that the two world-scale plants approved by Alberta in 1980, one by Petalta, and the other by Shell-Nova, would be the last such plants to use oil as a feedstock.

Other Fuels

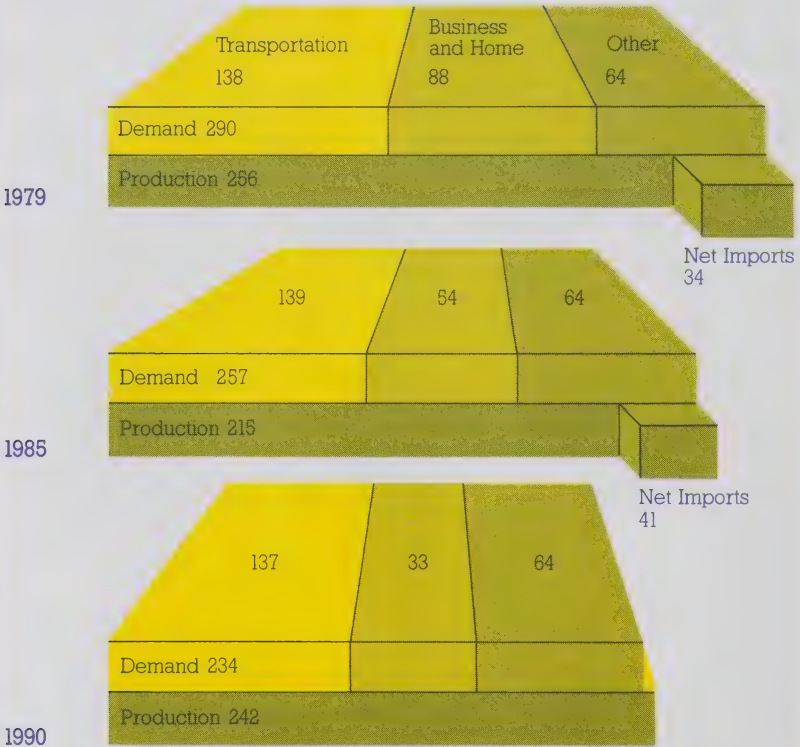
The major federal thrust in replacing oil is geared towards the substitution of natural gas and propane at this time since these are surplus fuels, which can be used easily to replace oil and are economically competitive. Other initiatives taken by the Government include many in the conservation and renewable energy field discussed under those chapter headings.

Other alternate fuels, such as compressed natural gas (CNG), ethanol, alcohol fuels, methanol, new hydrocarbon fuels from natural gas, coal and wood wastes could also be used in the future.

The development of many of these alternatives, however, is just beginning. At this point many are too expensive to produce on a commercial basis. Most need further research and development. In order to stimulate and encourage their development the Government of Canada released a *Discussion Paper on Liquid Fuel Options* in the fall. It discusses the various options and advantages, and the potential for these alternatives to oil.

Canadian Oil Supply and Demand (NEP Projection)

Thousands of cubic metres per day



CONSERVATION

Reducing Waste

An aggressive pursuit of energy conservation is the most immediate, and the least costly way to gain the time Canada needs to adjust our energy situation. This can be accomplished by reducing wasteful use of energy, especially oil.

Since 1975 the Government of Canada, working with provincial governments and industry, has been developing and implementing policies and programs to promote the conservation of energy. These have emphasized increased public awareness through information, demonstrations and incentives, and have provided money for research and development to increase energy efficiency.

Government expenditures on all conservation programs increased substantially during 1979-80. Federal expenditures were \$208 million while provincial expenditures increased to \$43.6 million, as compared to \$82 million and \$13.5 million respectively in 1978-79. The money is used to support efforts in the conservation of energy in the main end-use sectors: construction, transportation, industrial production in both the private and public sectors.

Industry

Several programs in the industrial sector are designed to improve energy efficiency in existing and planned plants; make better use of materials and energy that one otherwise wastes; and develop processes, equipment and products requiring less energy to manufacture or use.

Industry, working through 16 government-industry task forces, achieved, at the end of 1979, its 1980 goal by reducing energy use per measured unit of industrial output by 12 per cent from a 1972 base. In May 1980 the task forces announced their second five-year target: to improve energy efficiency per unit of output, by a total of 23 per cent over the 1972-85 period.

The Energy Bus Program, which provides on-site computerized energy audits to industry, business and institutions, was expanded during the year to include all provinces. These audits, provided under federal-provincial agreements, are conducted to assist companies to identify ways of improving energy-use efficiency. They have resulted in identifying average savings of 20 per cent for each site inspected.

In addition, a nationwide series of industrial seminars and technical workshops were presented in 1980 to increase awareness of the need for and benefits of energy conservation, and to also provide technical information on energy conservation projects.

The Industrial Energy Research and Development Program provides up to 50 per cent of the cost of approved projects for developing more energy-efficient processes for the industrial sector.

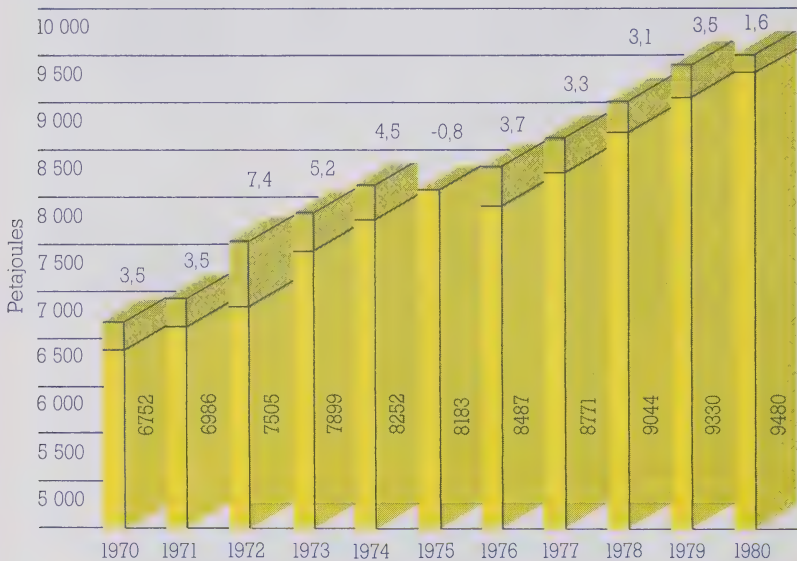
Buildings

In the residential sector the Canadian Home Insulation Program (CHIP) provides a taxable grant to householders of up to \$500 to help cover costs of insulation material and labour. During fiscal year 1980-81 CHIP funding was \$191 million, and approximately 500 000 houses were re-insulated under the program. In 1981-82 funding will increase to \$265 million annually.

To date, over 300 000 people have used the free computerized home insulation analysis provided by the federal government's Ener\$ave advisory service, and 100 000 have received additional advice through the program's toll-free "Heatline."

Under present constitutional arrangements, the Government of Canada's role in housing is limited to providing financial assistance. One of these measures is the provision of insurance of residential mortgages under the *National Housing Act*. To encourage conservation, any new residential unit for which federal financial support is sought after July 1, 1981 must meet federal energy-efficiency standards.

Total Energy Consumption 1970-80



Note: Excluding biomass.

To further stimulate construction of low energy housing, the federal government has announced funding of \$6 million to support the design and construction of 1000 super energy-efficient housing units across Canada during the next two years. Last year 14 such homes were built in Saskatchewan in co-operation with the provincial government.

Other than housing, the Government of Canada is encouraging the establishment of conservation task forces on the use of energy in buildings.

They have allocated \$100 000 for administrative support. The task forces will be organized by building types. One such task force is already operational in health care facilities.

It is planned to establish similar task forces for office buildings, hotels and restaurants, stores and shopping centres, and churches. In addition, a new federal-provincial program to demonstrate and promote retrofiting of commercial buildings is expected to be launched during 1981. This program will include a series of workshops in major cities.

Transportation

To promote greater awareness of conservation in the transportation sector, the Ener\$ave Car Computer Program, which compares the projected five-year fuel costs of new cars, toured major exhibitions across the country. Demonstrations that show energy and dollar savings possible through good driving habits and proper car maintenance are being incorporated into the program. Demonstrations of van-pooling and ride-sharing programs were also implemented in five provinces during the year.

Further steps to increase automobile fuel conservation were announced in the National Energy Program. The Government intends to legislate new vehicle fuel-consumption standards appropriate to Canadian conditions. Voluntary standards have been in effect since 1978; the legislation will provide a basis for setting standards beginning in 1985. Improvements in automobile fuel consumption since the mid-1970s are beginning to be reflected in total gasoline consumption.

Public Sector

The Internal Conservation Program continued as an effective effort to reduce energy consumption of the federal government through stricter control of energy use and improved equipment maintenance. The objective is to reduce the total energy consumption of the federal government by 10 per cent on an adjusted base from the 1975-76 level and to hold that reduced level for 10 years. This target has been achieved and indications are that it will be surpassed.

During 1979-80 the Government of Canada, in line with commitments to the International Energy Agency, initiated a program to reduce actual oil consumption by the federal government by 5 per cent during the year; the level achieved was 6.6 per cent.

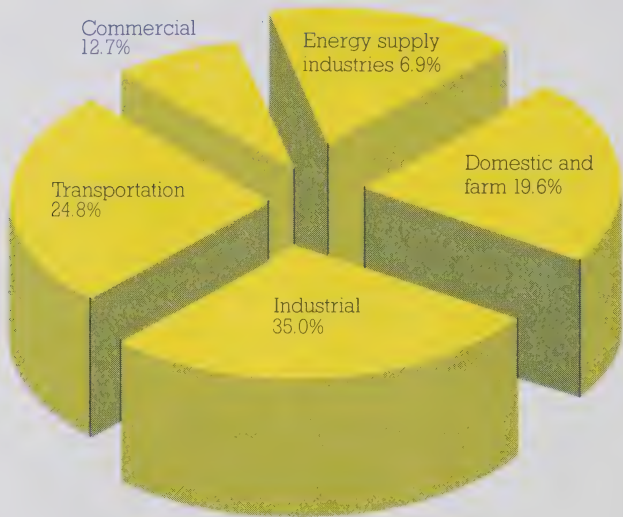
Other Measures

Tax incentives have also been provided to encourage conservation. Certain equipment designed to conserve energy or to develop renewable energy continues to be exempt from federal sales tax. The Energy Conservation Equipment Fast Write-Off was expanded during the year to cover a broader range of appliances. Among the equipment included are materials for small-scale hydro projects, heat-recovery equipment, some forms of heat distributors and solar energy equipment.

Efficient use of energy is a worldwide concern. To help find solutions and share experiences the Government of Canada has been actively

involved in the International Energy Agency's conservation committee. In 1980 Energy, Mines and Resources Canada sponsored an international tour of energy efficient homes in Canada; tour participants included delegates from IEA member countries, the provinces and the Housing and Urban Development Association of Canada (HUDAC). Canada has also participated in specific information exchanges with other countries, including the United States, Venezuela, Hungary, Papua – New Guinea and Jamaica.

Consumption of Secondary Energy



ELECTRICITY

Convenient and Versatile

Electricity is a *secondary fuel*, the product of conversion processes that derive energy ultimately from either *primary fuels* or *ambient energy sources*.

Examples of primary fuels are coal, oil, natural gas, uranium and biomass (animal and plant material, including, most notably in Canada's case, wood and wood wastes). All are used in Canada to some extent to generate electricity. Primary fuels are converted to electricity in *thermal power plants*, where they are burned to raise steam, which in turn drives turbogenerators. A *nuclear power plant* is a type of thermal power plant, where the controlled fissioning ("splitting") of the nuclei of uranium atoms is the source of heat.

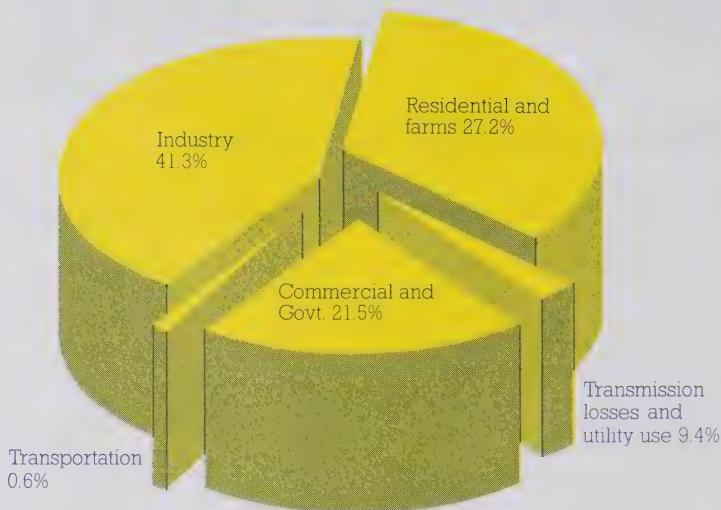
Examples of ambient energy sources are hydraulic (the mechanical energy contained in a mass of water), wind, geothermal and solar. Hydraulic energy is converted to electricity in a *hydroelectric power plant*, which utilizes the energy stored by damming rivers or seawater (in the case of a *tidal power plant*). Wind energy is converted into electricity by means of wind turbines. Geothermal energy is the heat emitted within the earth's crust, manifested in hot water or steam that can be captured to drive turbogenerators. Solar energy is converted to electricity by means of photovoltaic cells.

Electricity is a highly versatile energy source that can be conveniently used for a wide range of purposes because it can be readily converted into other forms of energy — light, heat and mechanical energy (in motors). Overall, some 36 per cent of the energy consumed in Canada is delivered in the form of electricity. Canada has an impressive natural endowment of rivers, and this has given rise to extensive development of hydroelectricity, a renewable energy source.

Demand for electricity is basically a function of population growth, economic activity and the price of electricity relative to competing fuels such as oil and natural gas. In the 25 years preceding 1973 the annual rate of growth in electricity demand was quite stable at about 6 to 7 per cent. Since 1973, when world oil prices began their sharp escalation, the annual growth rate of electricity demand has fluctuated considerably, but the average has only been about 4.2 per cent. This lower growth rate was caused mainly by reduced economic growth, increasing electricity prices and the impact of energy conservation measures. Forecasts for the next 20 years indicate that this generally lower rate of growth in electricity demand will continue, given the outlook for population growth, economic activity, reduced primary energy consumption and rising prices for all forms of energy.

However, the proportion of energy delivered in the form of electricity is expected to increase as Canadians switch from increasingly expensive oil to more abundant and relatively less expensive alternatives. While the

Electricity Consumption



1970s saw a very rapid increase in the price of electricity, it is expected that price increases during the 1980s will be substantially slower, probably about the rate of inflation, making electricity a more attractive alternative to oil for space-heating purposes.

Sources

Currently, about 69 per cent of the electricity produced in Canada comes from hydro sources, 22 per cent from fossil fuels (coal, oil and natural gas) and 9 per cent from nuclear power.

There are wide regional variations in the sources of electricity production. Nova Scotia, for example, is quite heavily dependent on oil, which is the primary source for about 40 per cent of the electricity generated in the province. Alberta and Saskatchewan rely primarily on coal for about two thirds of their electricity production. Quebec, Manitoba and British Columbia produce virtually all of their electricity from hydro sources. Ontario's electricity supply is generated from a variety of sources: coal, 26 per cent; nuclear, 31 per cent; and hydro, 39 per cent.

The evolution of fuel use for electricity generation will tend to increase the contribution by coal and nuclear sources, while the use of oil and natural gas declines. In the Atlantic region, coal, hydro and nuclear electricity-generation will displace imported oil. Quebec is committed to the further development of its massive James Bay hydro resources. Ontario will be expanding its nuclear power resources for the next decade. In the West, regional coal and hydro resources are expected to be more than sufficient to meet the region's projected electricity requirements.

Production, Consumption and Exports

Total Canadian electricity production for 1980 was 367 TWh (terawatt-hour), an increase of 4.1 per cent over 1979. Domestic consumption was 339 TWh, an increase of 5.2 per cent over 1979. Exports declined 3.8 per cent from the previous year to 30 TWh, about 8.2 per cent of total national electricity production.

The Ontario Royal Commission on Electric Power Planning (the Porter Commission) completed its five-year study and issued its final report. The Commission recommended that the system expansion plan of Ontario Hydro should be based on an anticipated growth range for peak capacity of 2.5 to 4.0 per cent/year to the year 2000. It also urged that Ontario should keep its electrical development options open, so that the power system will have the flexibility to withstand any sudden changes in demand or security of fuel supply.

The Council of Maritime Premiers and the federal Energy Minister announced that it has been decided not to proceed with the establishment of the proposed Maritime Energy Corporation. It was agreed, however, to establish a co-ordinating committee comprising representatives of the three provinces' utilities, and observers from the federal and the three provincial governments. The committee's responsibilities will be limited to technical

Electricity Consumption 1980

Megawatt-hours per capita

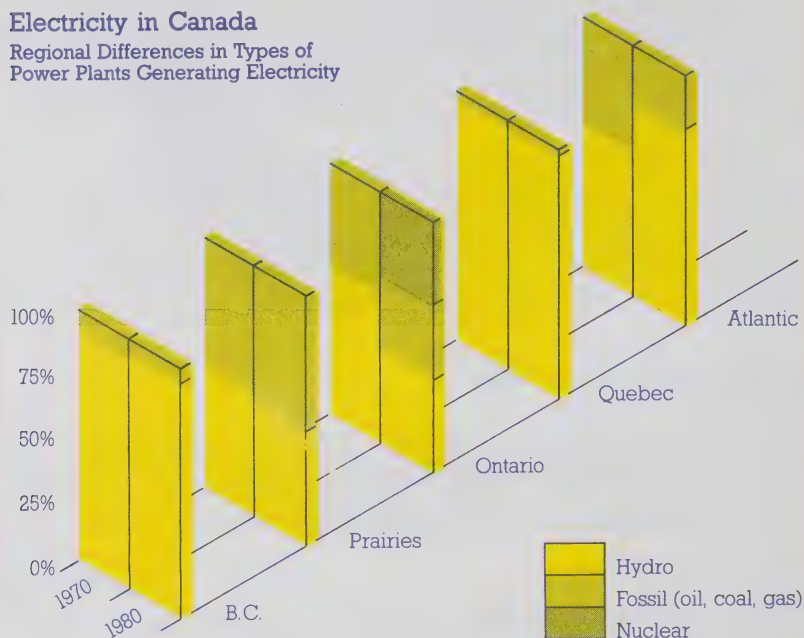


and operational co-ordination among the utilities, but discussions are continuing on further measures to promote co-operation on a broader range of energy matters.

British Columbia Hydro's Peace Canyon hydro project was officially opened, after six years of construction and an estimated investment of \$510 million. When in full production the project will generate 3.5 billion kWh (kilowatt-hour) of electricity annually, which is equivalent to 13 per cent of the electricity B.C. Hydro sold to its customers in 1979.

Electricity in Canada

Regional Differences in Types of Power Plants Generating Electricity



Construction of a low-head hydro tidal-power demonstration plant began at a site in the Annapolis Basin of Nova Scotia. The project will test a 17 MW(e) (megawatt—electric) straight-flow turbine, the largest of its kind in the world, to determine whether it is suitable for use at other potential low-head hydro sites throughout Canada, including large-scale development of tidal power in the Bay of Fundy. Scheduled for completion in 1983, the demonstration project will cost an estimated \$46 million, of which \$25 million will be contributed by the federal government under an agreement with the Province of Nova Scotia.

Studies continued into the feasibility of constructing a Western Power Grid that would link Alberta, Saskatchewan and Manitoba. The proposed grid would displace much of the Prairie requirements for new coal-fired electricity generating plants: Manitoba now has 3600 MW(e) of installed hydro capacity, with a further 6100 MW(e) yet to be developed.

The Board of Directors of the Lower Churchill Development Corporation (LCDC) recommended in July that the corporation proceed

Electricity
Terawatt-hours

	1970	1975	1979	1980
Canadian Production	205	273	352	367
Canadian Consumption	202	266	323	340
Imports	3	4	2	3
Exports	6	11	31	30
Net Exports	3	7	29	27

with a 618 MW(e) hydro development at the Muskrat Falls site, 2.48 km downstream from the existing Churchill Falls hydro site in Labrador. The report to the shareholders—the Government of Newfoundland (51 per cent) and the Government of Canada (49 per cent)—followed a series of technical, marketing, economic, environmental and financial analyses. The federal government subsequently announced in its National Energy Program that provision had been made for an equity contribution of up to \$200 million plus federal credit support to ensure that debt financing of the project can be obtained at acceptable rates. It was estimated that the project, including a direct transmission link to the Island of Newfoundland, would cost \$3.2 billion and take five and one-half years to construct.

COAL

Making a Comeback

A generation ago, coal was the energy backbone of the world's industrial economies. In 1950 it accounted for 49 per cent of the world's primary energy supply with oil at 33 per cent. By 1978 the figures were 18 per cent and 55 per cent respectively.

1 metric tonne (t) = 1.10 short tons
0.98 long tons

Now that the "cheap oil" era has ended, coal is receiving increasing worldwide attention as an alternative to oil.

Coal is consumed in Canada mainly for the generation of electricity (thermal coal, accounting for about 75 per cent of total coal consumption) and for cokemaking in the steel industry (metallurgical coal, accounting for most of the remaining 25 per cent of total coal consumption). Other industrial uses for coal are as yet small, though changes in relative fuel prices and the technology of coal-burning could enhance its competitiveness with other fuels.

Currently coal supplies about 9.3 per cent of Canada's total primary energy consumption. Regionally, it is most important in Saskatchewan (21.5 per cent of primary energy consumption), Alberta (15.2 per cent) and Ontario (15.9 per cent).

About 15 per cent of the nation's electricity supply is produced from coal. As a proportion of provincial electricity supply, it accounts for 70 per cent in Alberta, 65 per cent in Saskatchewan, 26 per cent in Ontario and 19 per cent in Nova Scotia.

Expansion of coal-fired electricity generation in the West, Ontario and Nova Scotia is expected to be the main factor in increased coal consumption over the next 10 years, increasing coal's share of total national primary energy consumption.

Fluidized-Bed Combustion

Development of fluidized-bed combustion plants with clean-burning, environmentally-acceptable systems is an important technical step toward greater use of coal. The fluidized-bed system eliminates up to 90 per cent of sulphur dioxide emissions and substantially reduces emissions of oxides of nitrogen—pollutants that contribute to the cause of acid rain. It also has the advantage of having lower capital investment requirements than other pollution control systems. A fluidized-bed combustion heating plant will be installed in the Armed Forces Base at Summerside, P.E.I. as the first application in Canada. Later a utility-scale plant may be built in Cape Breton to utilize safely and economically the region's high-sulphur coals. The British Columbia Hydro and Power Authority is also examining the possibilities for the next stage of this technical development, a pressurized

unit, for application later in this decade to the large Hat Creek low-rank coal deposit.

Coal can be converted into substitute natural gas and useful fuel gases as well as liquid fuels. It could also supply the thermal requirements of oil sands and heavy oil plants, thus increasing the yield from these sources. The direct hydrogenation of coal can produce a range of products such as fuel oils, transportation fuels and chemical feedstocks. All these processes would require large capital investments, and they may not be economically competitive for many years. The continued availability of natural gas suggests that the production of substitute natural gas from coal will not be needed in Canada for some years to come.

Production, Consumption and Reserves

Coal production reached 36.7 million tonnes in 1980, an increase of 11 per cent over the same period in 1979. This production is valued at \$943 million, compared to the 1979 value of \$836 million.

Alberta is Canada's leading coal-producing province, with a total output of 17.4 million tonnes during 1980. Production figures for the other provinces were: British Columbia, 10.2 million tonnes; Saskatchewan, 6.0 million tonnes; Nova Scotia, 2.7 million tonnes; and New Brunswick, 439 000 tonnes.

Canadian coal exports continue to show strong growth. In 1980 they amounted to 15.3 million tonnes, an increase of 12 per cent over the same period in 1979. The bulk of the exports is metallurgical coal. However, in the

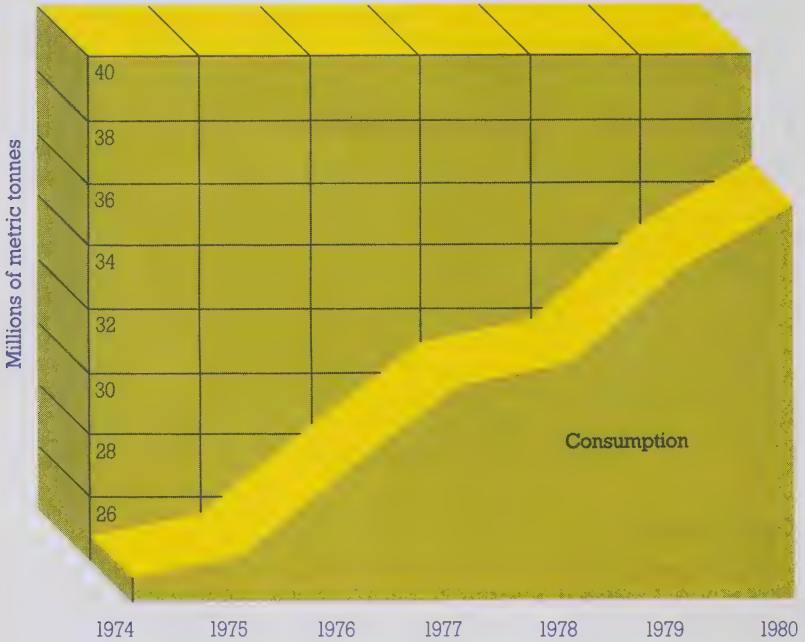
Coal Resources



future, exports of thermal coal are expected to grow substantially as foreign buyers seek Canadian coal as an alternative to oil.

Canadian imports during 1980 declined by about 9 per cent to 15.8 million tonnes reflecting increased use of coal from western Canada in Ontario for thermal power generation.

Coal in Canada



In December 1979, the latest assessment of Canada's coal resources and reserves was published by Energy, Mines and Resources Canada. It is estimated that measured resources of immediate interest are 16.8 billion tonnes of bituminous coal, 30 billion tonnes of subbituminous coal and 3.6 billion tonnes of lignitic coal. Mineable reserves were estimated to be 5.6 billion tonnes of bituminous coal, 7.3 billion tonnes of subbituminous coal and 3.2 billion tonnes of lignitic coal.

On September 15, 1980, the Minister of Energy, Mines and Resources, the Honourable Marc Lalonde, released a *Discussion Paper on Coal* at the 33rd Canadian Conference on Coal held in Vancouver. The paper set out the options open to Canadians in the development of their coal industry, and the Minister invited comments from the industry and from the public at large. Copies of this paper are available from Energy, Mines and Resources Canada, Ottawa.

International Target

In June the Venice Economic Summit (the United States, the United Kingdom, France, West Germany, Italy, Canada, Japan) declared that the seven nations intended, as a group, to double coal production and use by 1990. The summit leaders added that: "We are conscious of the environmental risks associated with increased coal production and consumption. We will do everything in our power to insure that increased use of fossil fuels, especially coal, does not damage the environment."

In May, the *World Coal Study*—a private international study in which Canadian experts participated—presented a set of forecasts of Canadian coal production and consumption. The "base case" projected Canadian consumption of between 82 and 121 million tonnes of coal equivalent by the year 2000. This would represent between 16 and 20 per cent of the nation's primary energy consumption in the year 2000, implying together with projected exports Canadian coal production levels three to five times higher than production levels at the time of the study.

Lingan Two, the second unit in Cape Breton's huge four-unit, coal-fired electrical generating complex, came on stream in the summer of 1980, one year earlier than originally planned. The 150 MW(e) station will consume about 400 000 tonnes of coal annually, displacing the equivalent of more than 254 000 m³ of imported oil.

In announcing the National Energy Program in October, the federal government committed itself to a package of measures designed to speed the development of the Atlantic region's coal resources to reduce dependence on oil. The federal government will provide up to \$150 million over the next five years to support the commercialization of new environmentally acceptable coal-use technology, including the demonstration of fluidized-bed combustion in a utility-scale generating station in Cape Breton. Funds will also be provided for exploratory tunnelling and assessment of the Donkin coal field in Nova Scotia, and for an expanded regional research and development program in mine safety, coal utilization and coal testing.

During 1980 negotiations continued for contracts under which up to 8 million tonnes of coal would be exported annually from northeastern British Columbia to Japan. The development would involve the construction of a

Coal

Millions of metric tonnes

	1970	1975	1979	1980
World Production	3 009.1	3 279.5	3 703.9	n.a.
Canadian Production	15.1	25.3	33.0	36.7
Canadian Consumption	25.7	25.5	34.8	37.3
Imports	17.6	15.8	17.5	15.9
Exports	4.0	11.4	13.7	15.3
Net Imports	13.6	4.4	3.8	0.6

Note: Production and exports do not equal consumption and imports due to industrial stockpiling.

new rail line into the coal field northeast of Prince George upgrading of the rail line between Prince George to Prince Rupert and the construction of a new coal port at Ridley Island near Prince Rupert.

In southeastern British Columbia it was announced that several mines plan to expand their productive capacity and several new contracts were signed. To accommodate these and other forecasted new coal exports in the 1980s, the federal government announced plans to greatly increase the coal capacity of Roberts Bank south of Vancouver. Several Alberta-based coal producers were also in the final stages of developing plans for new or expanded coal production.

URANIUM & NUCLEAR ENERGY

Policy Review

The Government of Canada undertook an extensive internal review of its nuclear policies and programs with respect to the nuclear industry in 1980. The review, the results of which are expected to be released in 1981, is intended to examine ways of making Canada's nuclear program more effective in achieving its three basic goals: to share the benefits of the Canadian-developed CANDU reactor system with other nations; to ensure that Canadian nuclear technology is used for peaceful purposes only; and to further develop and apply nuclear technology at home for the benefit of the Canadian people.

The foundation of the Canadian nuclear program is the CANDU (Canada Deuterium Uranium) reactor, which uses deuterium (heavy water) as both moderator and coolant, and natural (unenriched) uranium as the fuel. The CANDU system was developed 25 years ago and had its first large-scale commercial application in 1971, when the first unit of the Pickering, Ontario, Nuclear Generating Station achieved full-power operation.

There are three operating commercial nuclear stations in Canada, all located in Ontario: Pickering "A" (four reactors), Bruce "A" (four reactors) and Douglas Point (one reactor). With a total installed capacity of 5248 MW(e), the three stations accounted for one third of the province's electrical generation in 1980; Ontario Hydro's requirements in 1980 were about 1000 tonnes of uranium.

The CANDU reactors in Ontario continued to turn in remarkable performance records. In terms of lifetime capacity factor, which is the nuclear industry's measure of performance, six of the top eight reactors in the world at the end of 1979, out of 114 reactors of generating capacity greater than 500 MW(e), were CANDUs from Ontario. Bruce Unit 3 was the world leader.

Nuclear stations under construction or committed in Canada are Pickering "B" (four reactors), Bruce "B" (four reactors) and Darlington (four reactors) in Ontario; Gentilly 2 (one reactor) in Quebec; and Point Lepreau

1 metric tonne (t) (uranium metal)	=	1.299 short tons (uranium oxide)
1 cubic metre (m ³)	=	220.00 Imperial gallons 6.29 U.S. barrels
1 metre (m)	=	3.28 feet 39.37 inches

(one reactor) in New Brunswick. As they come on stream, between 1982 and 1991, these new plants will increase Canada's nuclear power generating capacity by an additional 9879 MW(e). When all the plants are operational, Canada's total uranium requirements would be about 2500 tonnes/year.

Canada has also exported two commercial-scale CANDU units to Argentina and Korea. These will come on stream in the next few years. At the end of 1980, negotiations were close to completion with Romania on the first two units of a CANDU program for that country. Provision of further units in Korea and new units in Mexico was also under discussion.

Beyond 1990, the prospects for further nuclear power development in Canada remain unclear. Uncertainties about the growth of electricity requirements, the economics of nuclear power as compared to various alternative energy sources in different regions, and continued public debate concerning the appropriateness of expanded nuclear development are major issues yet to be resolved. Significantly expanded nuclear power capacity will also require a safe means for long-term disposal of nuclear wastes, which is one of the main areas of current nuclear research and development in Canada. Joint research by the Government of Canada, through Atomic Energy of Canada Limited, and the Government of Ontario, through Ontario Hydro, is aimed at assessing the basic safety and environmental aspects of a proposal to isolate radioactive wastes deep in stable rock formations of the Canadian Shield. Only when it is shown that this disposal concept is sound, will the research program consider actual selection of a site for a repository.

Uranium (Tonnes U)^a

	1975	1977	1979	1980
World Reserves ^b	1 080 000	1 650 000	1 850 000	n.a.
World Production	19 130	28 850	38 000	50 000 ^c
Canadian Reserves ^b	144 000	167 000	215 000	230 000
Canadian Production	3 563	5 794	6 817	7 050 ^p
Canadian Shipments ^d	4 679	5 787	6 530	6 368 ^p
Domestic Requirements	n.a.	560 ^e	980 ^e	1 000 ^e
Destined for Export	n.a.	5 227	5 550	5 368 ^p

p - preliminary e - estimate

Sources: EMR Canadian Minerals Yearbooks; Uranium in Canada, 1979 Assessment of Supply and Requirements, EMR, EP 80-3; NEA/IAEA, Uranium Resources, Production and Demand, OECD, Paris (December 1979 and earlier).

- Notes: a) 1 metric ton of elemental uranium (1 tonne U) is equivalent to 1,2999 short tons of uranium oxide (U₃O₈).
b) "low cost" Reasonably Assured Resources as defined by the NEA/IAEA.
c) Estimated production capability.
d) Shipments of uranium (U) in concentrates from ore processing plants. Where shipments exceed (fall below) production, the balance comes out of (enters) inventory.

Production

Uranium production in 1980 was an estimated 7050 tonnes U, an increase of 3.4 per cent over production in 1979. Mines in Ontario accounted for about two thirds of this production, and mines in Saskatchewan about one third.

Shipments of uranium from production and inventory declined marginally from 6530 tonnes U in 1979 to 6368 tonnes U in 1980. However, the value of shipments increased by 3.6 per cent to an estimated \$638 million.

Exports

While uranium and nuclear technology are important exports for Canada, they are governed by policies designed to ensure their applications to peaceful purposes only. Under the latest enunciation of this policy, made in 1976, exports to nations that do not possess nuclear weapons are restricted to those which either ratify the Non-Proliferation Treaty or otherwise accept international safeguards on their entire nuclear programs.

Canada is one of the largest uranium exporters in the world. Of the 6368 tonnes U shipped by Canadian producers in 1980, some 84 per cent was destined for export markets, primarily in Japan and western Europe.

At the end of 1980, total future export commitments of all Canadian producers were 49 500 tonnes U. These exports are permitted within a policy framework that protects the long-term supplies of the domestic nuclear industry. The policy ensures a 30-year reserve of nuclear fuel for all existing and committed reactors in Canada, as well as those planned to start operation in the following 10-year period.

Uranium Resources

The Uranium Resource Appraisal Group (URAG) of Energy, Mines and Resources Canada completed its sixth annual (1979) assessment early in 1981.

It reported that Canada's "Reasonably Assured Resources" of uranium, mineable at prices of \$130/kg (kilogram) U or less were estimated at 230 000 tonnes U. Assuming a uranium price limit of \$200/kg U, the estimate would be 259 000 tonnes U.

URAG also reported that Canada's Estimated Additional Canadian Resources of uranium were estimated at 381 000 tonnes U, assuming a uranium price limit of \$130/kg U. If the higher price limit of \$200/kg U were assumed, the comparable figure would be doubled to 770 000 tonnes U.

The Atomic Energy Control Board (AECB), the federal agency responsible for the regulation of the uranium-producing and nuclear power industries, announced new policies governing public access to information held by the Board. Under the new policies, the Board will make available to the public documents that are incorporated into and form part of any licence or approval of nuclear facilities. The Board will also, on request, allow access to supporting documents filed with licence applications. The new policy was formulated in response to increasing public demands for information related to the regulation of the uranium and nuclear industries, and is a first step by the federal government toward developing a fully open regulatory process.

Major Studies

The International Nuclear Fuel Cycle Evaluation (INFCE), a major two-year study in which 66 nations participated, released its final report in early 1980. INFCE concluded that the contribution of nuclear power to world energy supply will continue to grow into the twenty-first century, and that fast breeder reactors can be expected to play an increasingly important role after the turn of the century. The study indicated that the CANDU reactor is generally competitive with light water reactors in terms of economics, safety and environmental impact, and superior to current light water reactors in efficiency of uranium utilization.

The Ontario Royal Commission on Electric Power Planning (the Porter Commission) released the conclusion and recommendations of its five-year study. Many of its recommendations concerned nuclear power. While the Commission was satisfied that the CANDU reactor is safe "within reasonable limits", it called for strengthened safety procedures in reactor operations. The Commission also recommended that further steps be taken to enhance public confidence in nuclear energy technology.

The Government of British Columbia imposed a seven-year moratorium on uranium exploration and mining activity in the province, thus curtailing the work of the Royal Commission of Inquiry into Uranium Mining (the Bates Commission). The government, however, allowed the Royal Commission to complete its report and submit it by the fall of 1980.

Eldorado Nuclear Limited, a federal Crown corporation engaged in the mining and refining of uranium, announced it had cancelled plans to build a

Uranium Resources



uranium refinery near Warman, Saskatchewan because it was unable to negotiate extensions on land options for the proposed site. Earlier, a Federal Environmental Assessment Panel had ruled that, while the proposed refinery was technically and environmentally acceptable, approval to proceed would be withheld until more was known about the social impact of the project on nearby residents. Eldorado is now examining other potential sites in Saskatchewan.

Amok Ltd., began mining its "D" Zone uranium orebody at Cluff Lake, Saskatchewan. The operation is expected to produce 1500 tonne/year U. The deposit is one of the richest in the world.

The Government of Saskatchewan appointed a five-member board of inquiry to examine Key Lake Mining Corporation's proposal to develop Saskatchewan's Key Lake uranium deposits and to recommend conditions under which the project should be permitted to proceed. The Board completed its inquiry late in 1980 and submitted its report to the provincial government early in 1981. The company hopes to commence construction of its surface facilities in 1981; production could begin in 1983 at a rate of up to 4600 tonnes/year U.

The short-term uranium market outlook deteriorated throughout 1980 due largely to a continuing decline in nuclear power expectations in most countries. The consequent reduction in short-term uranium market opportunities, together with sales from utility inventories, contributed to considerable downward pressure on uranium prices. By year-end, spot-market price levels, as reported in the United States, had fallen more than 25 per cent to less than \$US 78/kg U (\$US 30/lb U_3O_8). In Canada, however, average prices under contracts, including spot sales made by Canadian producers for deliveries in 1980, were determined to be about \$US 114/kg U (\$US 44/lb U_3O_8).

Included in this determination were prices for 1980 deliveries under earlier contracts, where provision was made for annual price renegotiation.

RENEWABLE ENERGY

New Markets

During 1980, the development of renewable energy sources in Canada received a major boost with the introduction of the National Energy Program. Federal expenditures for renewable energy programs, which were \$70 million in fiscal year 1980-81, will exceed \$150 million next year. These funds will be available for research, development and demonstration projects in renewable energy, other than large-scale hydroelectricity.

The federal government's major thrust to take Canadians off oil will provide new markets for renewable technologies. Under the Canada Oil Substitution Program (COSP), conversions to solar, wood or wind energy are eligible for a grant of 50 per cent of conversion costs, up to a maximum of \$800 per residential unit.

The federal government also announced the establishment of a new Canadian alternative energy corporation called CANERTECH, the mandate of which will be focused on renewable energy and conservation technology. Initial funding of \$20 million for this corporation has been budgeted for its work in supporting Canadian businesses engaged in this field through joint ventures and equity investments. Assistance in commercialization and marketing will also be made available.

New developments in renewable energy will also be demonstrated in the Arctic Community Demonstration Program announced in October, through which the federal government will organize and finance renewable energy systems in a sample northern remote community.

Continuation of a special emphasis on renewable energy in Prince Edward Island was announced in 1980 with the extension of the P.E.I. Conservation and Renewable Energy Agreement with the federal government. Federal support will be undertaken at a three-year cost of \$7.5 million.

Biomass

Canada has a significant potential for the production of energy from biomass, a source that encompasses forest and agricultural products and residues, as well as municipal wastes.

Residues from forest and farm operations in Canada are the best candidates for increasing the energy contribution from biomass. Residues of forest product mills in particular (pulp and paper, lumber) are available on site and are being used in Canada for many of the energy needs of the forest industries. Combustion for heat, steam or electricity (through cogeneration) is increasingly accepted by the sector. One pulp mill in

Ontario is even recovering industrial grade ethanol from its waste, and a plywood mill in northern Ontario is obtaining heat through a wood gasifier.

In 1980 the federal government announced several programs to assist in converting energy systems to use biomass fuels, in demonstrating new technologies, and in research and development of biomass energy. In addition to assistance discussed in the introduction to this chapter, there have been increased allocations of funds for research and development in the production of gaseous and liquid fuels from biomass feedstocks.

The Forest Industry Renewable Energy Program (FIRE), established in 1978, has provided grants that total \$32.6 million (up to December 31, 1980). Over 30 projects were funded in 1980, resulting in oil displacement of over 318 000 m³/year. As a result of all the conversions to date assisted through FIRE, it is estimated that the 56 pulp mills involved are displacing 590 000 m³ of oil equivalent per year by burning their wood residue. Under the National Energy Program, FIRE has been expanded significantly, to include all industrial and commercial users who wish to use any biomass alternative.

Estimated Federal Expenditure on Renewable Energy*

Fiscal Year 1981-82

Current	\$Millions
Research and Development	22.0
Procurement - Purchase and Use of Solar Heating (PUSH)	20.0
Federal-Provincial Demonstrations	14.0
Forest Industry Renewable Energy Program (FIRE)	20.0
Sub-total	76.0

National Energy Program

Research and Development	To be announced
Extension to FIRE	13.0
Solar Residential Hot Water Demonstration	3.5
P.E.I. Agreement	2.5
Off-Oil (Wood and Solar) Grants	42.0
Remote Community Initiative	2.0
CANERTECH CANADA	To be announced
Sub-total	63.0
TOTAL	139.0

*Excludes spending on energy-efficient building design—passive, solar tax expenditures, alternative liquid fuels and other spending by the Canadian International Development Agency on renewables.

Total Federal spending on renewables in fiscal year 1976/77 was \$4.6 million.

Federal-provincial demonstration agreements on conservation and renewable energy are now underway with most provinces. Biomass-related projects account for 15 per cent of the projects funded to date.

The long-term objective for biomass energy in Canada is to double its present contribution of 3.1 per cent of primary energy by 1990 and to reach up to 10 per cent by the end of the century. It is expected that most of this contribution will result through direct combustion of solid and reconstituted wood residues. However, the technologies for the production of gaseous and liquid fuels from all biomass feedstocks are expected to improve.

Solar

About 32 per cent of Canada's energy demand is in the form of low-grade heat below 100°C, the majority for water or space heating for industrial, residential and agricultural applications. Some of this demand could be met by solar energy.

Swimming-pool heating by solar methods is already competitive with conventional fuels. The low temperatures and the inexpensive solar equipment required to raise the water temperature only 5 to 10°C have made this the most economical application of solar energy to date.

Solar water heating for domestic, industrial and commercial use offers a large potential to reduce conventional fuel demand as energy costs rise and solar heating equipment becomes more competitive. To encourage solar usage in the commercial and industrial sectors, solar heating systems are now eligible for a two-year write-off against corporate income. For the residential sector, the federal government announced in 1980 an accelerated demonstration of solar domestic hot water systems. The \$5million program will co-ordinate the installation of 1000 packaged solar domestic water heaters across the country.

During 1980, Energy, Mines and Resources Canada initiated a consultative process that will lead to the development of a National Strategy for Solar Energy Development. A discussion paper on this subject will be released in 1981.

Solar technologies will benefit from the new programs described at the beginning of this chapter, such as the off-oil programs, the establishment of CANERTECH, and the increased research and development funding.

Some other federal government activities in support of solar energy include:

- Providing \$10 million for research and development of solar energy by the National Research Council for 1980-81.
- Developing a market for the solar industry through the Purchase and Use of Solar Heating (PUSH) Program. Public Works Canada administers the program to purchase solar equipment for federal government buildings. About \$10 million has been spent to date.
- Financing of demonstrations of renewable and conservation technologies through federal-provincial agreements administered by Energy, Mines and Resources Canada.
- Developing solar equipment performance standards under a contract by the Canadian Standards Association to the National Research Council. The NRC is expanding its program to develop prototype systems suitable for mass production by industry.
- Opening of a national solar test facility in Mississauga, Ontario.

- Providing accelerated tax write-offs against corporate income for solar heating and small hydro equipment.

Geothermal

Heat within the earth's crust offers potential as an energy source in the long term. Accessible geothermal energy resources generally occur in two regions of Canada.

Some areas of the Prairies cover sedimentary rocks containing water at 80°C. An experiment at the University of Regina supported by the federal government is studying the use of this subsurface water, with heat exchangers, to provide space heating.

The second area with a good potential for geothermal energy is the Rocky Mountains, where volcanic action brings rock temperatures into the 100 to 300°C range within accessible drilling depths. Surveys are under way to locate and assess the geothermal potential of these localities. The federal government and British Columbia Hydro are drilling at Meager Mountain, north of Vancouver, to assess the feasibility of constructing a geothermal electric power station there.

Wind

Work by the National Research Council, in collaboration with provincial utilities and engineering companies, has given Canada a lead in the development of the vertical-axis wind turbine, which employs an "egg-beater" rotor configuration.

During 1979-80, six field trials of small wind turbines in the 1 to 5 kW range were carried out in special purpose and remote applications. The Atlantic Wind Test Site in Prince Edward Island opened in 1980 to provide test facilities to the manufacturers of small wind machines.

Two 50 kW machines were in operation in 1980—one at Holyrood, Nfld., and the other at Swift Current, Sask.—to test mechanical and electrical components. Similar installations and demonstrations are planned for Ontario, Manitoba and British Columbia.

A 200 kW wind turbine demonstration project was completed at Wreck Cove by the Nova Scotia Power Corporation.

The largest machine in operation is the 230 kW wind turbine generator jointly run by the National Research Council and Hydro-Quebec in the Magdalen Islands. The 40 metre high wind turbine is capable of supplying electricity for the non-heating needs of 50 households. It is fully automatic and connected to the island's 36 MW generation system. An industry group, under NRC contract, has calculated favourable cost estimates for similar but larger machines in the megawatt power range. A decision has been made by the federal government to construct a prototype of this size in collaboration with Hydro-Quebec. Called Project Aeolus, the wind turbine built will provide enough energy to supply the non-heating needs of 600 households.

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The data presented in Energy Update 1980 are expressed in metric units, except in chapter on Electricity, where Imperial units are still recognized. For readers who wish to know the approximate equivalents in Imperial or other common units, the following tables may be of assistance.

CONVERSION FACTORS

Metric unit	Equivalent (approximate)
1 metre (m)	3.28 feet 39.37 inches
1 kilometre (km)	0.621371 miles
1 cubic metre (m ³) (oil)	220.00 Imperial gallons 6.29 U.S. barrels
1 cubic metre (m ³) (natural gas)	35.30 cubic feet
1 kilogram (kg)	2.20 pounds
1 metric tonne (t)	1.10 short tons 0.98 long tons 1000.00 kilograms
1 joule (J)	0.009482 Btu
1 gigajoule (GJ) (natural gas prices)	0.93209 million Btu (gross heating value)

Note: Natural gas prices have been determined on a gross or higher heating value (dry basis) at 101.3 kPa (kilopascal) and 15°C.

Prefix	Symbol	Value	Common expression
kilo	k	10 ³	thousand
mega	M	10 ⁶	million
giga	G	10 ⁹	billion
tera	T	10 ¹²	trillion
peta	P	10 ¹⁵	quadrillion



